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Applying IT to Healthcare: Humans, Errors, and a Data Quality Perspective

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ABSTRACT

Dramatic applications of information technology to healthcare have promised reduced medical errors and costs in the healthcare system. Much attention has focused on continuing to develop new applications, the features of the applications themselves, and the adoption of these applications. The questions of errors and costs in the health care system still persist. In this paper, we take a data and information quality perspective to redirect the question and the focus. This paper focuses on the errors, the data underlying these errors, and potential sources of these errors. We provide new concepts derived from integrating the areas of healthcare, cognitive science, behavioral science, and data quality. We further provide specific templates that can be used to facilitate organizations in reducing and avoiding the errors.

Keywords

Healthcare, errors, data, human, data quality, information quality, stakeholder, global data, local data, error template

1. INTRODUCTION

Dramatic advances and growth in the application of technology, in general, and information technology, in particular, have occurred in healthcare. Advances such as new technologically based procedures and new technologically driven diagnostic tools have contributed to improve the delivery of medical care. (Hu et al., 1999)

Nevertheless, even with all these advances two major issues continue to be of concern to the health care field: the unacceptable number of medical errors that occur daily and the continued escalating costs of health care (Kohn et al., 1999; Leape and Berwick, 2005; Berwick, 1995). Clearly some of the increased health care costs are related to medical errors. Malpractice insurance premiums increase and fear of litigation can lead to over testing of a patient which also adds to additional costs.

Again, the healthcare field has looked to information technology to provide assistance in addressing these problems. Initiatives, such as electronically stored medical records and automated order entry systems for medication (Ash et al. 2004), are examples.

There has been greater advocacy from the health care side for a systems approach to medical errors. This is reflected in a number of publications such as Wachter and Shojania [2004], the Institute of Medicine's Committee Quality Healthcare in America [1999,2001], and the National Academy of Engineering and Institute of Medicine's joint report on building and engineering/health care partnership [2005].

The majority of research and practice articles on applying IT to healthcare revolve around (1) the automation of a particular process or delivery of a new system (Bashshur et al., 2001), (2) the application of a specific technology to a specific medical problem or procedure, (3) descriptions of specific software intended to alleviate a specific problem (Gagnon et al., 2005), (4) to the problems of adopting and deploying specific IT in different health care environments (Raitoharju, 2006; Jayasuriya, 1998) and (5) to strategies that will overcome resistance to these new technologies and to the changes the technologies cause. Further, interest has grown in the field of e-health and the digitization and automation of patient records. This also appears to be true from the health care side. All these undertakings are important, useful, and have yielded some positive results.

We propose to take a slightly different perspective to the application of IT to health care and, more specifically, to the problems of errors. We combine constructs from the theory of errors with basic concepts and constructs from the area of data quality, to form the basis of this perspective. This paper gives an overview of the approach taken by briefly reviewing some basic concepts from the theory of errors, relating these to data quality and to medical errors, and lastly presenting the outline of a template, a framework, that will be used to identify both actual and potential sources of errors and aid in the prevention and/or correction of errors. Given that this is work-in-progress what we present are preliminary constructs and developments.

2. THE WRONG PATIENT CASE

An effective way to begin is to examine a case, analyzed by Chassin and Becher and extensively discussed by Wachter and Shojania [2004]. The Wrong Patient Case (WPC) below involves two individuals, Jane Morrison who on the day in question *was scheduled* for a cardiac electrophysiology study (EPS), an invasive procedure, to correct a heart problem and Joan Morris who the day before *had undergone* a procedure to correct a brain aneurysm and was *awaiting to be discharged*. The essence of the case is that because of a series of minor but cumulative "errors" Joan Morris, who was scheduled to be discharged, was subjected to the EPS procedure a day after having undergone the procedure to correct the brain aneurysm. It was only after the doctors undertook the heart procedure (EPS), could find nothing wrong with the heart and additional information on the patient was checked did it become apparent that the wrong patient had been worked on.

Below, we reproduce a listing of errors from the appendix in Wachter and Shojania [2004] and refer the reader to Wachter and Shojania [2004] for a complete discussion of this case.

List of the Seventeen Individual Errors in the Wrong Patient Case

1. An unidentified person on the telemetry floor misdirected RN_1 by saying "patient Morrison" was not on the floor (when she was) and by saying that she had been transferred to oncology (6:15 AM).

2. An unidentified person on the oncology floor misdirected RN_1 by saying the patient she sought (Ms. Morrison) was on the floor when she was not (6:20 AM).

3. An unidentified person on the oncology floor told RN_2 to bring her patient (Ms. Morris), the wrong patient) to the electrophysiology laboratory (6:30 AM).

4. RN_2 took her patient to the electrophysiology laboratory despite (a) the patient's objections, (b) the lack of a consent form and order in the chart, (c) lack of knowledge on her own part or that of her charge nurse that the procedure was planned (6:45 AM).

5. RN_1 failed to verify the patient's identity against the electrophysiology laboratory schedule when the patient arrived in the electrophysiology laboratory (6:45 AM).

6. RN_1 failed to recognize the significance of Ms. Morris's objections to undergoing the procedure (6:45 AM),

7. The electrophysiology attending physician failed to verify Ms. Morris's identity when he spoke with her by telephone, and he failed to understand the basis of her objections to the procedure (6:45 AM).

8. RN_1 failed to appreciate the significance of the lack of an executed consent form in the chart, especially given that the electrophysiology schedule stated that the correct patient (Ms. Morrison) had signed the form (6:45 to 7:00 AM).

9. The electrophysiology fellow failed to verify the patient's identity, failed to recognize the significance of the lack of pertinent clinical information in her chart, and failed to obtain consent that was informed (7:00 to 7:15 AM).

10. The electrophysiology charge nurse failed to verify the patient's identity (7:10 AM).

11. RN_3 failed to verify the patient's identity (7:15 to 7:30 AM).

12. The neurosurgery resident did not persist in obtaining a satisfactory answer to his question as to why his patient was undergoing a procedure about which he had not been informed (7:30 AM).

13. RN_4 failed to verify the patient's identity (8:00 AM).

14. The electrophysiology attending physicians failed a second time to verify the patient's identity when he did not introduce himself to Ms Morris at the beginning of the procedure (8:00 AM).

15. The electrophysiology fellow disregarded the fresh groin wound from Ms. Morris's cerebral angiogram the day before and started the electrophysiology procedure on the opposite side (8:00 AM).

16. A telemetry nurse (RN_5) and two electrophysiology nurses (RN_3 and RN_4) failed to verify the identities of the patients they discussed on the telephone (8:30 to 8:45 AM).

17. The electrophysiology charge nurse failed to persist in obtaining a satisfactory answer to her question of why no patient with the name Joan Morris appeared on the electrophysiology schedule (8:30 to 8:45 AM).

As presented above, one might conclude negligence on the part of many individuals. It is a good example, however, of the situation where a number of minor errors, if they occur as they often do in isolation, ordinarily would not be a problem. In this case, however, a whole series of minor errors converged to create a situation resulting in a major error.

Observe that many of the errors are, in essence, the transmission of data or information of poor quality. Looking further into this case we can identity a number of different types of errors. To identify and differentiate these errors we make use of Reason's [1990] theory and constructs of errors. We will first briefly present some of Reason's core concepts. Then we will return to the case and relate the sequence of events in the case to Reason's constructs.

3. HUMAN ERRORS IN GENERAL

In this section we discuss, at a generic level, some of the key concepts, constructs, and relationships relating to human errors. We base our discussion on the work of Reason (Reason, 1990) and his "theory of errors." We borrow extensively from this work, which has its foundation in the cumulative research of more than 100 years in psychology and reflects a cognitive science perspective.

We give a brief review of the most important constructs, concepts, and terms presented by Reason that directly apply to the topic of this paper. For in depth coverage of Reason's perspective, theories, and models, the reader is referred to Reason (1990).

Reason asserts that the major elements in the production of an error are the nature of the task and its environmental circumstances, the mechanisms governing performance, and the nature of the individual. One decomposition of error that Reason introduces is the concepts of slip, lapse, and mistake. We quote the working definitions of these terms given by Reason:

"Error will be taken as a generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency." (Reason, 1990, p9)

"Slips and lapses are errors which result from some failure in the execution and/or storage stage of an action sequence, regardless of whether or not the plan which guided them was adequate to achieve its objective." (Reason, 1990, p9) "*slips* are potentially observable as externalised actions-not-as-planned (slips of tongue,......), the term *lapse* is generally reserved for more covert error forms, largely involving failures of memory that do not actual manifest themselves in actual behavior and may only be apparent to the person who experiences them." (Reason, 1990, p9).

"Mistakes may be defined as deficiencies or failures in the judgmental and/or inferential processes involved in the selection of an objective or in the specification of the means to achieve it, irrespective of whether or not the actions directed by this decision-scheme run according to plan." (Reason, 1990, p9) Examples of mistakes, as well as, slips can be found in the discussion of the Wrong Person Case that follows.

Reason classifies errors as behavioral, contextual, and conceptual. He asserts that only at the conceptual level can we truly address the underlying causal mechanisms. (Reason, 1990, p10)

Reason (1990) also introduces the concepts of error type and error forms as follows:

"Error type relates to the presumed origin of an error within the stages involved in conceiving and then carrying out an action sequence." (Reason, 1990, p12)

The type of errors listed earlier are associated with different cognitive stages as follows:

Cognitive Stage	Primary Error Type
Planning	Mistakes
Storage	Lapses
Execution	Slips

Turning to error forms, we quote Reason directly: "...error forms are recurrent varieties of fallibility that appear in all kinds of cognitive activity, irrespective of error type." (Reason, 1990, p13) Examples of error forms are the biases that individuals introduce in their decisions and evaluations, such as, similarity and frequency biases.

The above constitutes a small piece of the rich theory and model, which Reason has proposed. Nevertheless, it will serve our purpose well.

4. ANALYZING ERRORS IN THE WRONG PATIENT CASE

We return to the Wrong Patient Case (WPC). By adding context to the list of errors in this case, the errors lose their sterility and a number of Reason's types emerge. We will examine some of these.

Table 1, below presents some of the errors from the case and their classification according to Reason's classes. The table is intended to illustrate the concepts and not be a detailed or complete analysis of the case. Note that any of these errors can occur at the behavioral, contextual, or conceptual level.

Table 1 – WPC Errors and Error Types

Primary Error type	Slips	Lapses	Mistakes
Cognitive Stage	Execution	Storage	Planning
Wrong Patient Case Errors (Item #)	#1. #2		#4, #7, #9

Given the generally hectic environment in hospitals, it is often difficult to keep track of patients. Patients are often moved without notification, and when crowding occurs, it is not uncommon to admit patients to a bed on a floor or wing that does not specialize in the patients condition. So, it is not difficult to understand RN_1's reaction in error #1. Specifically, RN_1 is applying an unwritten but acknowledged rule, albeit heuristic, that this is a common occurrence and it is nothing earth shaking. This would fall into Reason's category of "mistake." It is most probable that the individual who gave RN_1 the incorrect information has committed a "slip" although it is also possible that further information would indicate that this was a "mistake."

The information given to RN_1 by the ward clerk of the cancer unit was clearly incorrect. RN_1 informed the clerk that she needed "Morrison" for the EPS not giving the clerk any further information. The clerk, noting the name "Morris" on her white board told the nurse that "Morris" was on the floor and was ready for her EPS procedure. Here, again with the same caveat as above, we would classify this as a "slip."

Other "mistake" types are evident among the physicians and nurses throughout the case. Take item 7 above. The EPS nurse noted that Joan Morris, the wrong patient, was nervous. The nurse had the electrophysiology fellow (physician) speak to her. The fellow had seen Jane Morrison, the correct patient, the previous evening and had found that Jane Morrison was not anxious about the procedure. That she now expressed anxiety seemed odd to the fellow, but he attributed it to the fact that the lab could be a "pretty scary place" and attributed the patient's anxiety to this. An understandable assumption and conclusion but ones that do not excuse the lack of positive confirmation. Again, we see the application of a heuristic rule based on data of poor quality, more precisely faulty or missing data on the patient's identity.

It is difficult from the information on the case to detect any examples of lapses. The majority of the errors in this case can be classified as "mistakes." Nevertheless, each "mistake", occurring in isolation, would most likely have been detected and corrected. Unfortunately, the confluence of all these errors occurring in one case led to a major mistake.

5. THE MEDICAL DATA QUALITY TEMPLATE

A major examination of the system and its procedures, by the hospital, would be (and was) necessary to correct the systemic problems illustrated in the above case. Most all of the errors involved poor data/information quality. (We use data and information interchangeably in this paper. Not differentiating between the two does not materially affect this paper and, indeed, debating whether the two can be differentiated or not deflects attention from the main focus of this paper. Any such debate best takes place outside this paper. We understand that most managers differentiate the two; while, they do acknowledge that someone's data could be someone else's information.)

The template we intend to develop can be used to anticipate the types of problems illustrated in the previous sections, to aid in the analysis of root causes of the errors, to identify potential unintended consequences (Campbell et al. 2006), and to aid in the understanding, explanation, and correction of the errors. Our template is recursive in the sense that the same structure can be applied at different levels of detail. Thus, in the medical setting, it could be applied to a specialty unit, such as a cardiac unit; it could be applied to subunits such as the nursing staff and its work flow relationships within the cardiac unit; or it could be applied at a broader organizational level, such as, all the units involved in the Wrong Patient Case described earlier. Indeed, we suggest that it would be most useful at this broad level or higher because one of its features is the explicit identification of boundary lines and the communications that occur over these boundary lines.

Although its dimensionality can be increased, in our preliminary work we limit ourselves to a two dimensional structure. One dimension categorizes the type or scope of data as either local (to the organizational entity under study) or global. Given that the unit under study is defined, global data refers to data that the unit will use both internal to it and with external units. Local data refers to data that is for internal use. The second dimension enumerates the stakeholders or active participants in the units of the organization under study. This, of course, will change with the organizational context. For example, in the Wrong Patient Case, among the participants are the attending physicians, the surgeons, the nurses of the different units involved.

Using this template, one can deduce the data interactions between and among participants and also whether the data is local (relevant to the individual only) or global (relevant and important to other players). These boundary interactions then can yield important information regarding how data is interpreted by each player, how the data should be interpreted, the effect of misinterpretation or errors in the data, and a myriad of other implications. These can be used for analysis, for process improvement, and for data quality improvement. Application of the template to the context of the Wrong Patient Case (before it became a Wrong Patient Case) might have pointed out the different weaknesses in the system and what might go wrong when all the things that could go wrong line up and do go wrong. This, in effect, would be a failure mode/failure effect analysis when designing the system. This is essentially what the hospital ended up doing after the fact in its post mortem analysis and corrective action initiatives. The general structure of the template is shown below (Table 2):

Table 2 – Generic Template Structure

	Stakeholder 1	Stakeholder 2	Stakeholder N
Local Data			
Global Data			

We illustrate in Table 3 below, application of this structure to a simple subset of the WPC.

Table 3 – Template Applied to WPC

	Attending Physician	EPS Charge Nurse
Local Data	Technical knowledge of procedure	Technical knowledge of procedure and internal EPS administrative procedures
Global Data	Patient identity	Patient identity

This is clearly a simplistic example. It depicts the communication/data interface, the boundary, between the Attending Physician and the Charge Nurse in regard to one piece of data, patient identity. In terms of the EPS procedure, there were no errors, no slips, no lapses, no mistakes. The procedure was flawless. There was no problem with the local data, namely how to perform the operation. Unfortunately, it was performed on the wrong patient. Here we observe a problem in one piece of global data, namely the identity of the patient. Note that we can also observe the communication between the doctor and nurse. In discharging her administrative tasks, the charge nurse detected that it was possible the wrong patient was being subjected to the procedure. She went into the procedure room and inquired about the individual on the operating table only to be reprimanded by the physician who emphatically stated that this was "his patient!" We only use this example to illustrate how we suggest our template would identify potential problem areas, particularly across unit boundaries. Here, we see global data that should be incontrovertibly unambiguous. It is a potential trouble spot that can be anticipated and addressed as part of the system design. These type of analyses will also be necessary as increasingly the transmittal of information across such boundaries becomes automated.

In a real analysis finer categories of data and stakeholders can be introduced. Given its recursive nature, the template could be used in a hierarchical fashion to model different levels of the system analogous to the hierarchically related models of finer and finer detail (e.g. the leveling in Data Flow Diagrams). The above example is simply intended to illustrate the form of the template and its intended use.

6. CONCLUSION

This paper presents a series of new concepts and constructs from the perspective of data and information quality, which can be the basis of a practical and useful tool to the health care field as well as other organizational settings. This research explores the convergence of problems in health care with the cognitive basis for errors and concepts of data and information quality. The research initiative reported in this paper remains a work-in-progress.

For practice, the concepts presented here, when fully developed, should be applicable to any simple or complex work environments. For example, making use of the template presented here should allow for the capture and positioning of local data and local knowledge within the context of global data and global knowledge. We anticipate it will make the local data more meaningful, helps to align it with its possible global use, and accentuates its importance within a global framework. Developing the template in an organization also should aid in identifying and recording the operant data elements and related data in a proper context. Furthermore, it should aid in keeping the focus on identifying potential errors or areas that can give rise to errors and can suggest how, when, and where to apply possible remedies when errors arise. In short, it should be of help in root cause analysis as well as suggest areas of conceptual research into root causes. Further, with the increasing use of technology in all phases of healthcare, the suggested approach and template may aid in analyzing the effects of new technologies on the interfaces between and among stakeholders (users) and could be helpful in avoiding "unanticipated or unintended consequences" of applying the new technology.

For research, further studies of the relationship between the theory of errors and that of information quality we hope will yield new perspectives and knowledge that benefits both areas. The concepts and the template presented here must be refined, tested, and applied to different environments and different levels within an organization or extended organizations. For example, we intend to further develop the template and apply it to a large academic medical facility.

In sum, the integration of insights from the different areas and the resultant concepts and the templates presented in the paper, we hope, will initiate a new avenue of rich interdisciplinary research, benefiting from the research results of the different disciplines of healthcare, cognitive science, behavioral science, and information quality.

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